

APPARATUS FOR THE TRANSMISSION AND/OR RECEPTION OF DATA, AND METHOD FOR CONTROLLING THIS APPARATUS

5 The invention relates to an apparatus for the transmission and/or the reception of data, and more particularly to an apparatus of this kind which comprises protection means.

10 The transmission of digital data is performed through a great number of switches or routing devices which may be subject to failures. The failures may appear either in the links, i.e. in the wires, which are either electrical or optical, or in equipment such as terminating boards. In the context of the present description a link is a set of two lines, one for the incoming data, the other for the transmitted data. These two lines may be integrated into one single conductor, or may consist of two separate lines, for instance two optical fibres.

15 **Explanation about link protection:**

Generally, data are transmitted between transmission/reception equipment, such as exchanges, which are switching or routing devices, whereby two equipments are coupled by a plurality of links. A group of N working links are usually associated with one protecting link, in this case the protection is denoted as 1:N. When a failure or degradation is detected in a working link, this corresponding working link is replaced by a protecting link under the control of a protection circuit named "Automatic Protection Switching". According to ITU standard n° G.783, the number of protecting links between 2 transmission / reception equipment may amount to 1 protecting link for a maximum of 15 working links.

After repair of the failed working link, either this repaired link returns to the original state, or this previously working link becomes a protecting link .

30 A protecting link is normally not completely inactive. It is used to transmit signalling data about the integrity of the working links. These signalling data are, for instance, the K1,K2 bytes of the already mentioned ITU standard.

35 The protection ratio of the working links is variable. A protection ratio of 1:N means that 1 protecting link is provided for N working links. This ratio may be zero. In that case, no automatic protection mean is provided and the traffic through the failed working link is rerouted over other links routed to the same destination.

Explanation about board protection:

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Similarly, it is to be noticed that the term “coupled”, also used within this document, should not be interpreted as being limitative to direct connections only.

5 Thus the scope of the expression “ a device A coupled to a device B” should not be limited to devices or systems wherein an output of device A is directly connected to an input of device B. It means that there exists a link between an output of A and an input of B, possibly via other devices between A and B.

With the switching device or devices of the invention, the protection ratios
10 of the links and of the terminating boards are selectable independently from each
other. In other words, link protection and board protection are orthogonal.

In the preferred embodiment, each switching device comprises a 2 x 2 switch or a similar switch, such as a 4 x 4 switch.

15 The 2x2 switches have each four terminals, wherein one of which is connected to an input or output, another terminal is connected to the input or output of an active terminating board and a third terminal is connected to the corresponding input or output of a spare terminating board.

As it has been observed that the design of known equipment or exchanges are such that some failures may not be detected, such as failures in the connections provided for the replacement of a working link by a protecting link or a connection for replacing an active terminating board by a spare terminating board, in a particular embodiment, the invention takes advantage of the switching devices, more particularly the 2x2 switches or similar to test the continuity of the connection between the links and the spare terminating boards, a test function being incorporated in such spare terminating boards.

In known equipment, either the control and switching of the failing links, or the control and switching of the failing boards are not centralized. This causes interchanging messages over different boards to control and perform the switching function. This exchange of messages entails a waste of time and the risk of losing data.

In order to overcome this drawback, in an embodiment, the protecting controls are centralized. Therefore, with this architecture, it is possible to minimize the time required for replacing automatically a failed terminating board by a spare terminating board and to minimize the time for replacing a failed working link by a protecting link. Consequently, the risk of losing data is minimized.

Preferably, in order to allow a replacement of the switching devices, such as the 2 X 2 switches, without interrupting the traffic and to simplify the manufacture and the use of such exchanges, the 2x2 switches are installed on a panel, called an applique, together with the corresponding control means for these switches.

For the same reason of simplicity of manufacture and use, the wires or fibers connecting the switching devices to the terminating board are preferably installed on a single panel which will be called here a back panel.

The terminating boards are also preferably installed on a common terminating panel.

In an embodiment, the protection of the terminating boards is performed from the applique panel and controlled from the terminating panel and the control operation for protecting the links is performed on the terminating panel. It is recalled here that the protection of a terminating board comprises the step of replacing the defective terminating board by a spare terminating board through an appropriate modification of the connection(s) between the switching devices and the terminating boards. By protection of the links, it is meant here that the detection of failures of a link is performed on the corresponding terminating board as well as the generation of control signals requesting the replacement of a working link by a protection link, such as the transmission of bytes K_1 and K_2 according to the ITU standard n° G.783 , after which steps the final coupling to the spare link is performed.

It is recalled here that, before a repaired board can be put in service again, usually it has to be tested. This test is conventionally performed by an internal loop on the board, but the connections to the external links are not tested.

The architecture of this invention provides that a (repaired) board can be tested, including the external links, independent of other (test) boards.

Other features and advantages of the invention will appear with the description of the herein-appended drawings in which :

- figure 1 represents schematically an exchange according to the invention with one working link, one protecting link, one terminating board and one spare board,
- figure 2 represents the same exchange as the one shown on figure 1 but in a different operating mode, and

The example of the invention which will be described with the drawings is a switching or routing device for transmission and reception of digital data such as an equipment for transmission and reception of data according to the Internet 5 Protocol (IP). However, it can also be used in ATM, PSTN, or STM networks.

15 Link W is hereafter called a "working" link, which, in a 1:1 protection configuration is always coupled to a "protection" link. In a later paragraph, the more general case of 1:n protection will be dealt with, with which it is meant that one protection link is provided for n working links.

To the working link W is associated a protecting link P comprising also a forward link coupled to another input 10₃ and a return link coupled to another
25 output 10₄. Both links may again be integrated into one conductor. This protecting link P replaces the working link W in case of failure of the latter.

According to the preferred embodiment of the invention, to each line end is associated a 2x2 switch and all the 2x2 switches are coupled and controlled in such a way that, in case of failure of a terminating board 12₁, this active
35 terminating board 12₁ is replaced by a spare terminating board 12₂. Preferably, the 2x2 switches are used for testing, from the spare terminating board, the

reserved link(s) which is (are) used only in case of replacement of the active terminating board by the spare terminating board 12₂.

More precisely, as shown on figure 1, to the input end 10₁ of link W is associated a 2x2 optical switch 14₁ comprising four terminals 16₁, 16₂, 16₃ and 16₄, and second control means (26₁ and 41) for modifying the connection between these terminals. The switch 14₁ has two operating positions: in the first operating position, the terminal 16₁ is coupled to the terminal 16₃, and the terminal 16₂ is coupled to the terminal 16₄, as shown in thick full and broken lines respectively, and in the second operating position, the terminal 16₁ is coupled to the terminal 16₄, and terminal 16₂ is coupled to terminal 16₃, as is shown by the thin broken lines.

In the operating mode represented on figure 1 with thick lines, the connections 16₁-16₃ and 16₂-16₄ are used. In the operating mode represented on figure 2, the connections which are used are 16₁-16₄ and 16₂-16₃.

In a similar way, a 2x2 switch 14₂ is associated to the output end 10₂ of link W, and two respective 2x2 switches 14₃ and 14₄ are respectively associated to input 10₃ and output 10₄ coupled to link P.

In Fig. 1, the terminal 16₃ of switch 14₁ is coupled to an input 18₁ of a detection circuit 20₁ of the active terminating board 12₁. One output 22₁ of circuit 20₁ is coupled to the terminal 16'₃ of switch 14₂. The function of circuit 20₁ is, on one hand, to detect signal failures (SF) and signal degradation (SD) of the data received from input 10₁ and, on the other hand, to transmit the received data to a data transmission / reception circuit 24₁. When a signal failure or a signal degradation is detected by circuit 20₁, this SF or SD information is transmitted to a controller 26₁ on the terminating board 12₁ and this controller 26₁ provides a control signal to a request circuit 28₁ of the same board 12₁. This circuit 28₁ generates K₁ and K₂ requests which are the standardized bytes used for requesting the replacement of a working link by a protection link. These K₁ and K₂ bytes are transmitted through the protection link P as indicated by the thick black lines between circuits 28₁ and input 10₃ and output 10₄. The request circuit 28₁ has therefore one input 30₁ connected to the third terminal of switch 14₃ and one output 32₁ connected to the third terminal of switch 14₄.

In the operating mode represented on figure 1, the terminals 16₂ (16'₂) and 16₄ (16'₄) of switch 14₁ (14₂), and the corresponding terminals of switches 14₃ and 14₄ are not used for transmitting data or signalling. However, these terminals, as shown on figure 2, are used for transporting data and signalling

when the spare board 12₂ becomes active and the board 12₁ becomes a spare board. Moreover, the terminals 16₂, 16₄, 16'₂ and 16'₄ are used for testing the connections to the board 12₂. For this purpose, respective terminals 16₄ and 16'₄ of respective switches 14₁ and 14₂ are coupled to respective terminals 18₂ and 22₂, of detection circuit 20₂ of terminating board 12₂. Similarly, the fourth terminals of switches 14₃ and 14₄ are coupled to the terminals 30₂ and 32₂ of request circuit 28₂ of the terminal board 12₂. Circuits 20₂ and 28₂ of the terminating board 12₂ have the same functions as circuits 20₁ and 28₁ of the terminating board 12₁.

For the testing: of line 36₁ between terminal 16₄ of switch 14₁ and input terminal 18₂ of circuit 20₂; of line 36₂ between terminal 16'₄ of switch 14₂ and input terminal 22₂ of circuit 20₂; of line 36₃, between the fourth terminal of switch 14₃ and terminal 30₂ of circuit 28₂; and of line 36₄, between the fourth terminal of switch 14₄ and input terminal 32₂ of circuit 28₂, it is necessary that lines 36₁ and 36₂ are inside a closed loop and that lines 36₃ and 36₄ are also in a closed loop. For this purpose, terminal 16'₂ of switch 14₂ is coupled to terminal 16₂ of switch 14₁ and, in the same way, the second terminal of switch 14₄ is coupled to the second terminal of switch 14₃, as can be observed from Fig. 2.

Therefore, the testing of the continuity of lines 36₁ and 36₂ is realized from detection circuit 20₂ of spare terminating board 12₂ and the testing of continuity of lines 36₃ and 36₄ is realized by request circuit 28₂ of the spare terminating board 12₂.

In figure 1 and figure 2, the lines which are used for transmitting data and signalling are represented with black thick full lines and the lines which are tested, and not used for transporting data or signalling, are represented with thick dotted lines.

The 2x2 switches 14₁ and 14₂, which, in an embodiment where W and P present optical fibres consist of optical switches, are installed on a board 40₁. In the same way, the optical switches 14₃ and 14₄ are installed on a common board 40₂. The boards 40₁ and 40₂ are installed on a panel 42 called here an "applique" panel. The active connections or couplings 38₁, 38₂, 38₃ and 38₄ to the board 12₁ and the reserved connections 36₁ to 36₄ are realized on a panel 44 called here a "back panel". The terminating boards 12₁, 12₂ are installed on a "terminating panel" 46.

With this structure, each applique board 40₁, 40₂ can be replaced easily. In the same way, each terminating board 12₁, 12₂ can be replaced easily.

The exchanges of functions between boards 40_1 and 40_2 , and between boards 12_1 and 12_2 are done automatically. More particularly, when a fault is detected by controller 26_1 on the active board 12_1 , the controller 26_1 of the board sends a command signal to a priority logic circuit 41 between boards 40_1 and 40_2 in order to modify (switch over) the connections or couplings of the switches 14_1 , 14_2 and 14_3 , 14_4 . With this modification of the connections, which is represented on figure 2, the terminating board 12_2 , which was previously a spare board, becomes an active board and, reciprocally, the terminating board 12_1 , which was previously active, becomes a spare board. With these new connections or couplings, the data and the signalling are transmitted by the board 12_2 , and the board 12_1 is used to check the connections 38_1 to 38_4 which, on figure 2, are represented with thick dotted lines, the connections 36_1 to 36_4 being represented with black thick lines on this figure 2.

Preferably, the automatic protection switching, which replaces automatically a defective working link by a protecting link, is performed only on the terminating board 12_1 or 12_2 by means of circuits 28_1 and 26_1 , together constituting the first control means. The detection of defects is performed by detection circuit 20_1 , and the request for switching over from working link to protecting link is performed with the first control means, constituting of 28_1 and 26_1 , all being positioned on the same board. Consequently, the time for controlling the switch over can be minimized due to the fact that there is no delay to send the necessary control signals since these circuits are all on the same board and are not interfacing with other processors. This decentralised approach further adds to the speed.

When a new terminating board 12_1 will replace a previously defective board, while board 12_2 has already taken over, the connections 38_1 , 38_2 , 38_3 and 38_4 , and the circuits 20_1 and 28_1 of this new board 12_1 are used to check the correct operation of this new board. This checking operation may be performed in a minimized time due to the implementation of the checking circuit on the terminating board 12_1 itself, as is shown in figure 2.

The minimization of the replacement time and of the checking time is, of course, favorable to the minimization of data losses.

The exchange according to the invention may be used either with 1:1 or with 1+1 operation. As known, a 1:1 operation is such that the data are transmitted on the working link only and not on the protecting link. In the 1+1

operation, the data are transmitted on both links and, on the reception side, the data which are received with the best quality are selected.

In case of automatic protection switching, part of the functions of circuits 20₁ and 28₁ are exchanged and a switch 25₁ connects the data transmission circuit 24₁ from circuit 20₁ to circuit 28₁.

The example which has been described with figure 1 and figure 2 is the simplest example of embodiment of the invention with one protection link for one working link and one spare board for one active terminating board. More generally, it is possible to select, at will, the number of protecting links and the number of working links; the number of active and spare terminating boards may also be selected at will and the protection ratios of the links and of the terminating boards may be chosen independently from each other.

In the embodiment represented on figure 3, on the applique board 42 two working links and two protecting links are provided. In other words, to each working link is associated a protecting link. The forward working lines W₁, W₂ are connected to inputs 50₁ and 50₂, and the corresponding forward protecting lines P₁, P₂ are connected to inputs 50₃ and 50₄. The return working lines W'₁, W'₂ are connected to outputs 50₅ and 50₆, and the corresponding return protecting lines P'₁, P'₂ are connected to outputs 50₇ and 50₈.

The terminating panel 46 is provided with an active terminating board 52 and an identical spare terminating board 54.

Each terminating board 52, 54 is provided with a number of circuits 20, 28 equal to the number of working and protecting links. More precisely, the active terminating board 52 is provided with a first data or detection circuit 20 for the working link (W₁, W'₁), a first request circuit 28 for the protecting link (P₁, P'₁), a second data circuit 20' for the second working link (W₂, W'₂), and a second request circuit 28' for the connection and protection of the second protecting link (P₂, P'₂).

The 2x2 switches 14'_i of the applique panel 42 have their terminals connected in a similar way as terminals 16₁, 16₂, 16₃ and 16₄ in figure 1 and figure 2, more particularly the second terminal 16''₂ of the 2x2 switch 14'₁ is connected to the corresponding terminal of the switch 14'₅ on the return line W'₁.

For the rest, the operation of the exchange represented on figure 3 is the same as the operation of the exchange described with figure 1 and figure 2.

In the embodiment represented on figure 4, only one protecting link P" is provided for three working links W"₁, W"₂ and W"₃. On the terminating panel 46", one spare board is provided for one active board.

Therefore, on each terminating board 58, 60, the number of automatic protection circuits (APS) corresponding to circuits 20₁ (data or detection) and 28₁ (request) of figure 1 is four : one for each working link and one for the protecting link. These APS circuits have the references respectively 64, 66, 68 and 70. The circuits 64, 66 and 68 are data circuits (similar to circuit 20₁ of figure 1) and the circuit 70 is a request circuit (similar to circuit 28₁ of figure 1). In addition, a common processor, similar to 26₁ is also present on the termination board, although it is not represented in the figure in order not to overload it. To the data circuits 64, 66, 68 and 70 correspond a switch 72 having a similar function as switch 25₁ of figure 1, i.e. the switch 72 normally provides the transmission of the data through the circuits 64, 66 and 68 but when a working link is replaced by the protecting link P", the switch 72 transmits the data through the circuit 70 for the working link which has been replaced by the protecting link.

Due to the fact that there is only one protecting link for three working links, it is necessary to provide priority rules for the boards 58 and 60 in order to determine which working link must be protected when more than one working link is defective.

The connections between the 2x2 switches and between the applique panel and the terminating panel are similar to those described with figure 1 and figure 3.

Although on figure 4 the number of working links is three, it is clear that this number of working links may have any value, for instance up to seven as provided by the ITU standard n° G.783.

As already mentioned, it is not absolutely necessary that an automatic protection switching be provided. In other words, the number of protecting links may be zero. An example of such embodiment is represented on figure 5. In this embodiment, one spare terminating board 80 is provided for three active terminating boards 82, 84, 86.

Due to the absence of a protecting link, the connection between the 2x2 switches is slightly different from the connection represented on figure 1 to figure 4. More precisely, on the forward lines W'''₁, W'''₂, W'''₃, the fourth terminal 16'''₄ of switch 14'''₁ is coupled to the second terminal 16₂ of switch 14'''₂ and the fourth terminal of said switch 14'''₂ is coupled to the second terminal of switch

14'''₃. In a similar way, the switches 14'''_{1r}, 14'''_{2r}, 14'''_{3r} of the return line W'₁, W'₂ and W'₃ are connected in series, i.e. in the second terminal of switch 14'''_{3r} is connected to the fourth terminal of switch 14'''_{2r}, and second terminal of switch 14'''_{2r} is connected to the fourth terminal of switch 14'''_{1r}. The second terminal of switch 14'''_{1r} is connected to the second terminal 16'''₂ of switch 14'''₁.

The third terminals of switches 14'''₁ and 14'''_{1r} are connected to the input and output terminals of the terminating board 82. In the same way, the third terminals of switches 14'''₂ and 14'''_{2r} are connected to the input and output terminals of terminating board 84 and the third terminals of switches 14'''₃ and 14'''_{3r} are connected to the input and output terminals of terminating board 86. The input and output terminals of the spare terminating board 80 are connected to the fourth terminals of, respectively, the switches 14'''₃ and 14'''_{3r}.

Figure 5a shows the operation of the device of figure 5 in case of failures of terminating boards 82 and 84.

In this case, the 2x2 switches 14'''_{2r} and 14'''₂ are controlled in order that the link W'''₂, W'''_{2r} be coupled to the spare terminating board 80.

In spite of the failure of terminating board 82, the corresponding 2x2 switches 14'''₁ and 14'''_{1r} remain in their previous position. In other words, in this case, the second defective terminating board is not immediately automatically replaced because of the lack of extra-spare boards. In this situation, the control circuits are such that they establish a priority table to select the link which will be protected in case of failure of a number of active boards which is greater than the number of spare board (s).

Reference will now be made to figure 6 which represents an exchange according to the invention wherein one protecting link is provided for three working links and one spare terminating board is provided for three active terminating boards.

In order to simplify the representation, the forward and return lines of each link have been represented by a single line. Consequently, the pair of 2x2 switches which are associated, respectively, to the forward line and the return line have been represented by a single block 90_i. For instance, the block 90₁ of figure 6 which is associated to the end of the link W₁₀ comprises two 2x2 switches which are in fact connected like the switches 14'''₁ and 14'''_{1r} represented on figure 5.

This exchange comprises, on the applique panel 92, three identical sets or boards 94₁, 94₂ and 94₃ of equipment each having pairs of 2x2 switches 90_i

and the corresponding control circuits for the protection of the equipment on the terminating panel 96.

The board 94₁ is coupled to three working links W₁₀, W₂₀, W₃₀ and one protecting link P₁₀ and includes four pairs of 2x2 switches, respectively, 90₁, 90₂, 90₃ and 90₄, i.e. eight 2x2 optical switches. Similarly, the board 94₂ is coupled to three working links W'₁₀, W'₂₀, W'₃₀ and one protecting link P'₁₀ and the board 94₃ is coupled to links W''₁₀, W''₂₀, W''₃₀ and P''₁₀.

On the terminating panel 96, four terminating boards are provided, respectively, 98₁, 98₂, 98₃ and 98₄, the boards 98₁, 98₂ and 98₃ being active boards and the board 98₄ being a spare board.

Each of these terminating boards comprises automatic protection switching circuits like those of reference 20₁ and 28₁ and 26₁ as described with figure 1. The automatic protection switching circuits 100₁, 100₂, 100₃ and 100₄ are associated with the links, respectively, W₁₀, W₂₀, W₃₀ and P₁₀.

As the terminating panel 96 comprises only one spare board 98₄ for protecting the three sets of working links W₁₀, W₂₀, W₃₀, it is necessary to couple in series the switches of the boards 94₁, 94₂ and 94₃. More precisely, the switches 90₁ of board 94₁ are coupled in series with switches 90₁ of the two other boards 94₂ and 94₃ in order that all these sets of switches 90₁ be coupled to the protection circuits 100_i of the spare board 98₄.

The series connection or coupling is similar to the one described with figure 5.

The operation of this exchange represented on figure 6 is similar to the operation of the exchanges described with figure 4 and figure 5.

It is to be noted that, like for the embodiment of figure 5, it is necessary to provide priority rules for the protection of the sets of links associated to boards 94₁, 94₂ and 94₃, because there is only one spare board 98₄ for the three active boards 98₁, 98₂ and 98₃ and in case of failure of more than one active board, the priority order must automatically determine which of the link sets will be selected for protection.

Although in the embodiment described with figure 6, one protecting link is provided for N working links and one spare board is provided for the same number N of active boards, it is possible to select independently the number n of working links which will be protected by one protecting link and the number m of active boards which will be protected by one spare board.

Figure 7 shows the general configuration of an exchange wherein p applique boards $92_1, \dots, 92_p$ are provided. On each applique board 92_i , are coupled m sets of n links and to these m sets of n links are associated m active boards $98_1, \dots, 98_m$ and one spare board 98_{m+1} .

- 5 The number of 2×2 switches of the p applique panels may be easily calculated: to each link, corresponds two 2×2 optical switches; therefore, the total number of switches is $2nxm \times p$.

- 10 According to the present state of the art, the maximum value of n may be 8, the maximum value of m may be 7 and the maximum value of p may be 3. Of course, these maximum values are just given as an example.

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